500mA Fixed Output, Fast Response CMOS LDO with Shutdown

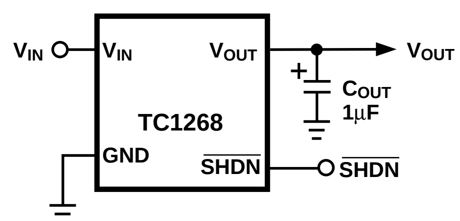
FEATURES

- Very Low Dropout Voltage
- Guaranteed 500mA Output
- High Output Voltage Accuracy
- Standard or Custom Output Voltages
- Over-Current and Over-Temperature Protection
- $\overline{\text{SHDN}}$ Input for Active Power Management
- $\overline{\text{ERROR}}$ Output to Detect Low Battery
- 5µsec (typ.) Wake Up Time from $\overline{\text{SHDN}}$

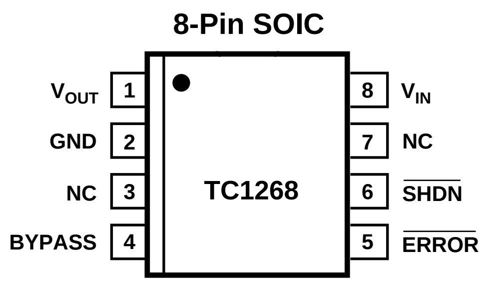
APPLICATIONS

- RAMBUS Memory Module
- Battery-Operated Systems
- Portable Computers
- Medical Instruments
- Instrumentation
- Cellular / GSM / PHS Phones
- Linear Post-Regulator for SMPS
- Pagers
- Digital Cameras

TYPICAL APPLICATION



PIN CONFIGURATION



GENERAL DESCRIPTION

The TC1268 is a fixed output, fast turn-on, high accuracy (typically ±0.5%) CMOS low dropout regulator. Designed specifically for battery-operated systems, the TC1268's CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 80µA at full load *(20 to 60 times lower than in bipolar regulators*!).

TC1268's key features include ultra low noise, very low dropout voltage (typically 350mV at full load), and fast response to step changes in load. The TC1268 also has a fast wake up response time (5 µsec typically) when released from shutdown. The TC1268 incorporates both over-temperature and over-current protection. The TC1268 is stable with an output capacitor of only 1µF and has a maximum output current of 500mA.

ORDERING INFORMATION

Part Number	Output* Voltage (V)	Package	Junction Temperature Range
TC1268-2.5VOA	2.5	8-Pin SOIC	– 40°C to +125°C

*Other output voltages and package options available. Please contact Microchip Technology Inc. for details.

ABSOLUTE MAXIMUM RATINGS*

Input Voltage 6.5V
Power Dissipation .... Internally Limited (Note 7)
Operating Temperature .... – 40°C < T_J < 125°C
Storage Temperature .... – 65°C to +150°C
Maximum Voltage on Any Pin .... V_{IN} + 0.3V to – 0.3V
Lead Temperature (Soldering, 10 Sec.) .... +260°C

*Absolute Maximum Ratings indicate device operation limits beyond damage may occur. Device operation beyond the limits listed in Electrical Characteristics is not recommended.

ELECTRICAL CHARACTERISTICS:

$V_{IN} = V_{OUT} + 1V$, $I_L = 100\mu A$, $C_L = 3.3\mu F$, $\overline{SHDN} > V_{IH}$, $T_A = 25°C$, unless otherwise specified. **BOLDFACE** type specifications apply for junction temperatures of – 40°C to +125°C.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Operating Voltage		—	—	**6.0**	V
I_{OUTMAX}	Maximum Output Current	(SOIC-8 TBD)	**500**	—	—	mA
V_{OUT}	Output Voltage	Note 1	— **V_R – 2.5%**	V_R ± 0.5% —	— **V_R + 2.5%**	V
$\Delta V_{OUT}/\Delta T$	V_{OUT} Temperature Coefficient	Note 2	—	40	—	ppm/°C
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$(V_R + 1V) \le V_{IN} \le 6V$	—	0.05	**0.35**	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} (Note 3)	—	0.002	**0.01**	%/mA
$V_{IN} - V_{OUT}$	Dropout Voltage (Note 4)	I_L = 100µA I_L = 100mA I_L = 300mA I_L = 500mA	— — — —	20 60 200 350	**30** **160** **480** **800**	mV
I_{DD}	Supply Current (Active Mode)	$\overline{SHDN} = V_{IH}$, $I_L = 0$	—	80	**130**	µA
I_{SHDN}	Supply Current (Shutdown Mode)	$\overline{SHDN}$ = 0V	—	5	—	µA
T_{WK}	Wake Up Time (from Shutdown Mode)	V_{IN} = 3.5V, V_{OUT} = 2.5V $C_{IN} = C_{OUT}$ = 1µF I_L = 250mA, (See Fig. 2)	—	5	10	µsec
T_S	Settling Time (from Shutdown Mode)	V_{IN} = 3.5V, V_{OUT} = 2.5V $C_{IN} = C_{OUT}$ = 1µF I_L = 250mA, (See Fig. 2)	—	15	—	µsec
PSRR	Power Supply Rejection Ratio	$F_{RE} \le$ 1kHz	—	64	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	1200	1400	mA
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	Note 5	—	0.04	—	V/W
eN	Output Noise	$I_L = I_{OUTMAX}$	—	260	—	nV/√Hz
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold		**45**	—	—	%V_{IN}
V_{IL}	$\overline{SHDN}$ Input Low Threshold		—	—	**15**	%V_{IN}
$\overline{ERROR}$ Output						
V_{MIN}	Minimum Operating Voltage		1.0	—	—	V
V_{OL}	Output Logic Low Voltage	1mA Flows to $\overline{ERROR}$	—	—	**400**	mV
V_{TH}	$\overline{ERROR}$ Threshold Voltage		—	0.95 x V_R	—	V
V_{HYS}	$\overline{ERROR}$ Positive Hysteresis	Note 7	—	50	—	mV

NOTES:
1. V_R is the regulator output voltage setting.
2. $T_C V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times DT}$
3. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
4. Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value measured at a 1V differential.
5. Thermal Regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a current pulse equal to I_{LMAX} at V_{IN} = 6V for T = 10 msec.
6. The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature, and the thermal resistance from junction-to-air (i.e. T_A, T_J, q_{JA}). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see *Thermal Considerations* section of this data sheet for more details.
7. Hysteresis voltage is referenced to V_R.

DETAILED DESCRIPTION

The TC1268 is a precision, fixed output LDO. Unlike bipolar regulators, the TC1268 supply current does not increase with load current. In addition, V_{OUT} remains stable and within regulation at very low load currents (an important consideration in RTC and CMOS RAM battery backup applications). Figure 1 shows a typical application circuit.

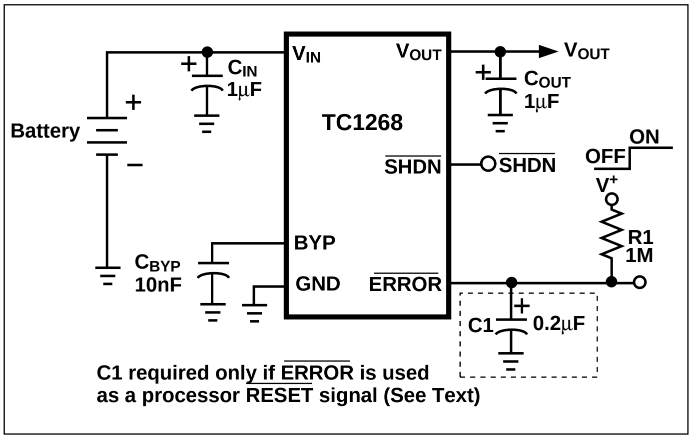


Figure 1: Typical Application Circuit

Turn On Response

The turn on response is defined as two separate response categories, **Wake Up Time (T_{WK})** and **Settling Time (T_S).**

The TC1268 has a fast Wake Up Time (5µsec typical) when released from shutdown. See Figure 2 for the **Wake Up Time** designated as **T_{WK}**. The **Wake Up Time** is defined as the time it takes for the output to rise to 2% of the V_{OUT} value after being released from shutdown.

The total turn on response is defined as the **Settling Time (T_S)**, see Figure 2. **Settling Time** (inclusive with T_{WK}) is defined as the condition when the output is within 2% of its fully enabled value (15µsec typical) when released from shutdown. The settling time of the output voltage is dependent on load conditions and output capacitance on V_{OUT} (RC response).

The **Wake Up Time (T_{WK})** is an important parameter to consider when using the TC1268 in RAMBUS applications. In this application, the bus voltage is held at 2.5V by a switching regulator during normal power conditions and can be switched to low power mode, where the TC1268 takes over and supplies the same 2.5V but at a much lower current (300mA). In order to not see the bus voltage droop during the transition from high power to low power, the TC1268 has a very fast wake up time of 5µsec to support the 2.5V rail. This makes the TC1268 ideal for applications involving RAMBUS.

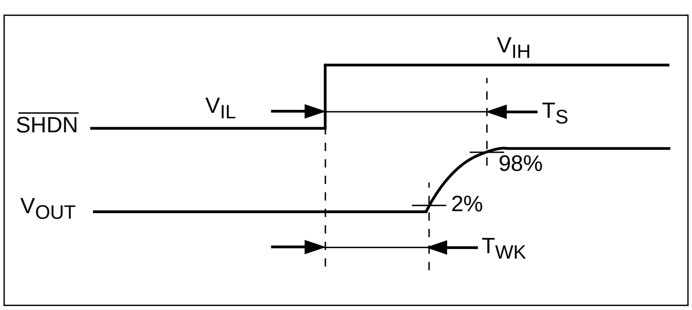


Figure 2: Wake Up Response Time

Bypass Input

A 10nF capacitor connected from the Bypass input to ground reduces noise present on the internal reference, which in turn significantly reduces output noise. If output noise is not a concern, this input may be left unconnected. Larger capacitor values may be used, but this results in a longer time period to achieve the rated output voltage once power is initially applied.

Output Capacitor

A 1µF (min) capacitor from V_{OUT} to ground is required. The output capacitor should have an effective series resistance of 5Ω or less, and a resonant frequency above 1 MHz. A 1 µF capacitor should be connected from V_{IN} to GND if there is more than 10 inches of wire between the regulator and the AC filter capacitor, or if a battery is used as the power source. Aluminum electrolytic or tantalum capacitor types can be used. (Since many aluminum electrolytic capacitors freeze at approximately –30°C, solid tantalums are recommended for applications operating below –25°C.) When operating from sources other than batteries, supply-noise rejection and transient response can be improved by increasing the value of the input and output capacitors and employing passive filtering techniques.

$\overline{\text{ERROR}}$ Output

$\overline{\text{ERROR}}$ is driven low whenever V_{OUT} falls out of regulation by more than – 5% (typical). This condition may be caused by low input voltage, output current limiting, or thermal limiting.

The $\overline{\text{ERROR}}$ threshold is 5% below rated V_{OUT} regardless of the programmed output voltage value (e.g., $\overline{\text{ERROR}}$ = V_{OL} at 2.375V (typ.) for a 2.5V regulator). $\overline{\text{ERROR}}$ output operation is shown in Figure 3. Note that $\overline{\text{ERROR}}$ is active when V_{OUT} is at or below V_{TH}, and inactive when V_{OUT} is above V_{TH} + V_H.

As shown in Figure 1, $\overline{\text{ERROR}}$ can be used as a battery low flag, or as a processor RESET signal (with the addition of timing capacitor C1). R1 x C1 should be chosen to maintain $\overline{\text{ERROR}}$ below V_{IH} of the processor $\overline{\text{RESET}}$ input for at least 200 msec to allow time for the system to stabilize. Pull-up resistor R1 can be tied to V_{OUT}, V_{IN} or any other voltage less than (V_{IN} + 0.3V.)

TC1268

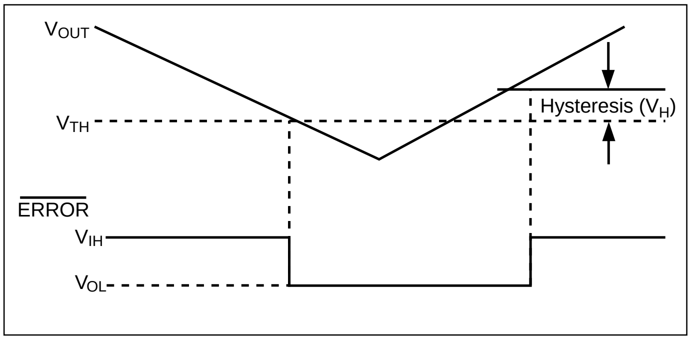


Figure 3: ERROR Output Operation

Thermal Considerations

Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds 160°C. The regulator remains off until the die temperature drops to approximately 150°C.

Power Dissipation

The amount of power the regulator dissipates is primarily a function of input and output voltage, and output current. The following equation is used to calculate worst case *actual* power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN})I_{LOADMAX}$$

Where:
P_D = worst case actual power dissipation
V_{INMAX} = maximum voltage on V_{IN}
V_{OUTMIN} = minimum regulator output voltage
$I_{LOADMAX}$ = maximum output (load) current

Equation 1.

The maximum *allowable* power dissipation (Equation 2) is a function of the maximum ambient temperature (T_{AMAX}), the maximum allowable die temperature (125°C) and the thermal resistance from junction-to-air (θ_{JA}).

$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$

Where all terms are previously defined.

Equation 2.

Table 1 shows various values of θ_{JA} for the TC1268 mounted on a 1/16 inch, 2-layer PCB with 1 oz. copper foil.

Table 1. Thermal Resistance Guidelines for TC1268 in 8-Pin SOIC Package

Copper Area (Topside)*	Copper Area (Backside)	Board Area	Thermal Resistance (θ_{JA})
2500 sq mm	2500 sq mm	2500 sq mm	60°C/W
1000 sq mm	2500 sq mm	2500 sq mm	60°C/W
225 sq mm	2500 sq mm	2500 sq mm	68°C/W
100 sq mm	2500 sq mm	2500 sq mm	74°C/W

NOTES: *Pin 2 is ground. Device is mounted on topside.

Equation 1 can be used in conjunction with Equation 2 to ensure regulator thermal operation is within limits. For example:

GIVEN:
V_{INMAX} = 3.3V ± 10%
V_{OUTMIN} = 2.5V ± 0.5%
I_{LOAD} = 275mA
T_{AMAX} = 95°C
θ_{JA} = 59°C/W

FIND:
1. Actual power dissipation
2. Maximum allowable dissipation

Actual power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN})I_{LOADMAX} = [(3.3 \times 1.1) - (2.5 \times .995)]275 \times 10^{-3} = \underline{314mW}$$

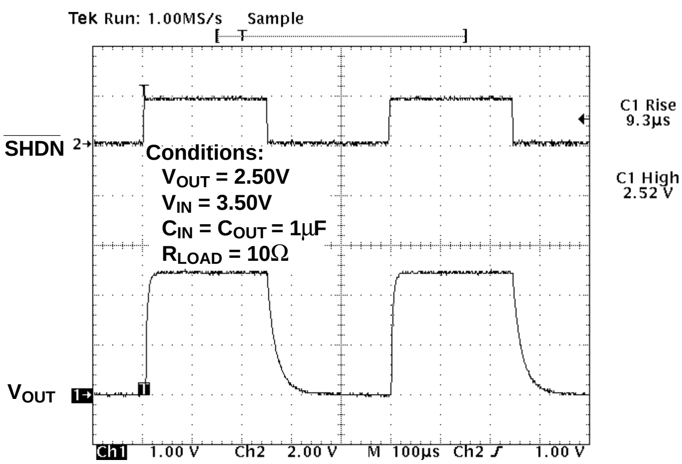
Maximum allowable power dissipation:

$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}} = \frac{(125 - 95)}{59} = \underline{508mW}$$

In this example, the TC1268 dissipates a maximum of only 314mW; far below the allowable limit of 508 mW. In a similar manner, Equation 1 and Equation 2 can be used to calculate maximum current and/or input voltage limits. For example, the maximum allowable V_{IN} is found by substituting the maximum allowable power dissipation of 508 mW into Equation 1, from which V_{INMAX} = 3.94V.

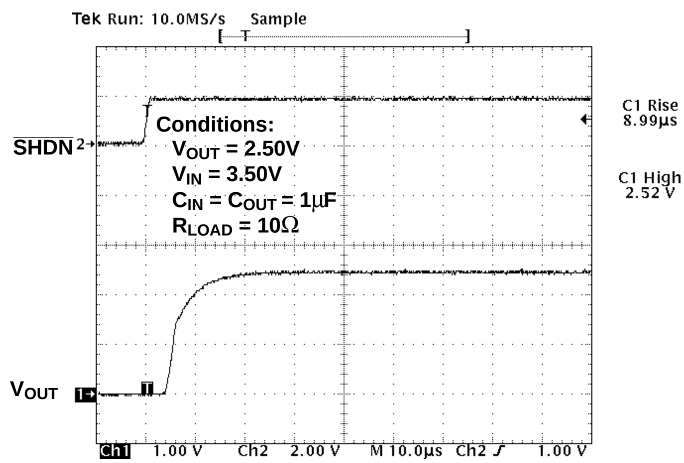
TYPICAL CHARACTERISTICS

Fast Response TC1268



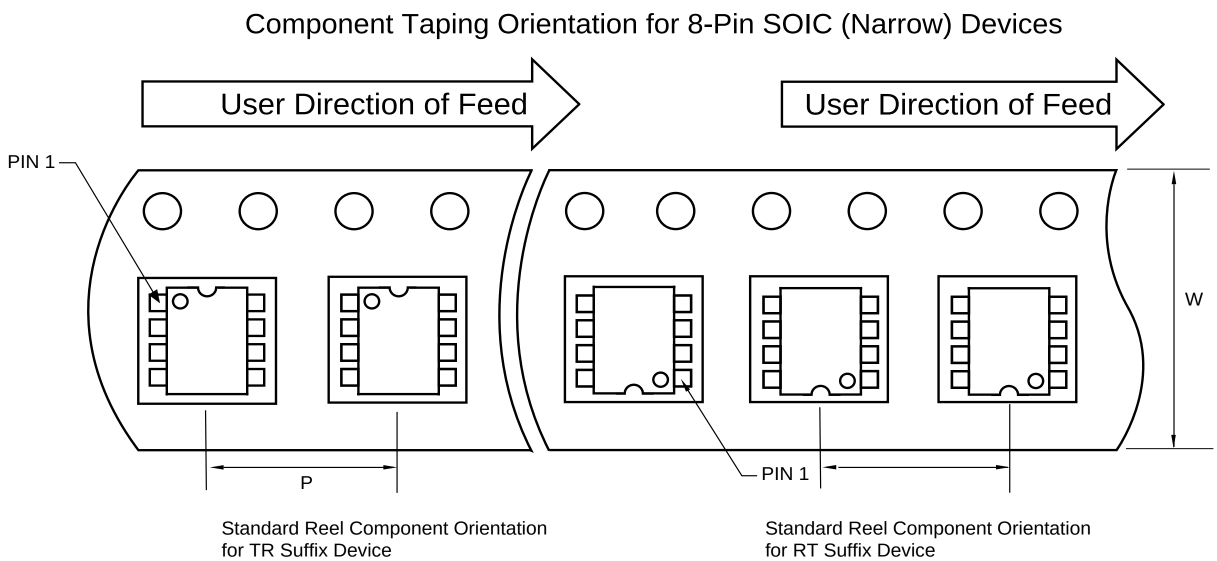
100µsec/DIV; 15µsec Rise Time

Fast Response TC1268



10µsec/DIV; 15µsec Rise Time

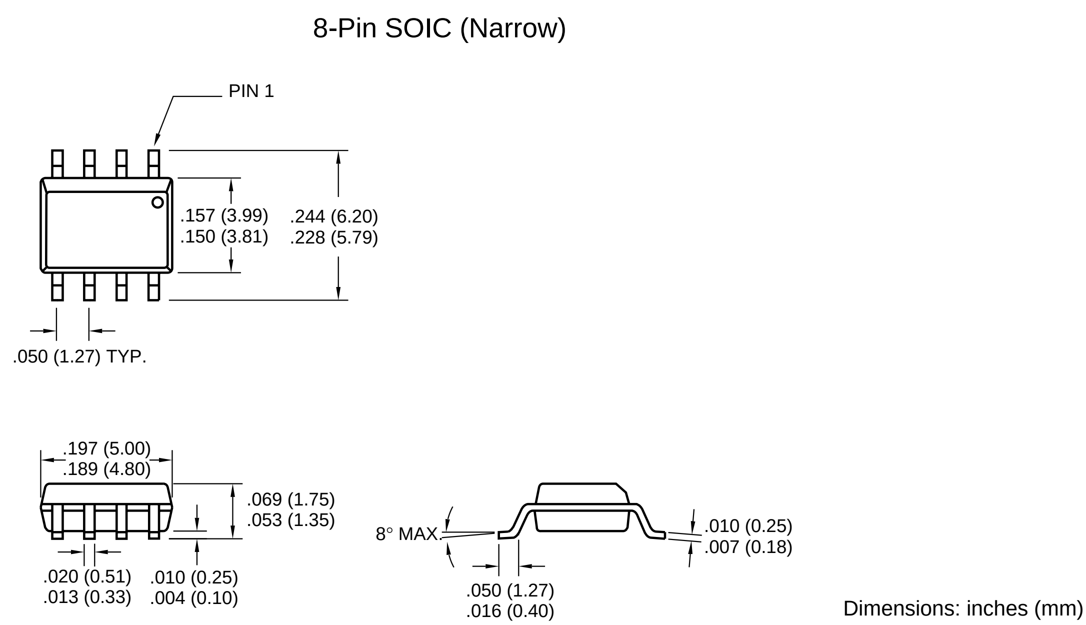
TAPING FORM



Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

PACKAGE DIMENSIONS



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